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PROPOSAL OF A METHODOLOGY FOR THE DESIGN OF OFFSHORE WIND FARMS

EUROPEAN GEOSCIENCES UNION
General Assembly 2010
Vienna, Austria, 02 – 07 May 2010

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AGENDA

1. INTRODUCTION
2. FACTORS TO BE CONSIDERED IN THE DESIGN OF OFFSHORE WIND FARMS
3. METHODOLOGY FOR THE DESIGN OF OFFSHORE WIND FARMS
4. CHECKING OF THE PROPOSED METHODOLOGY

AGENDA

1. **INTRODUCTION**
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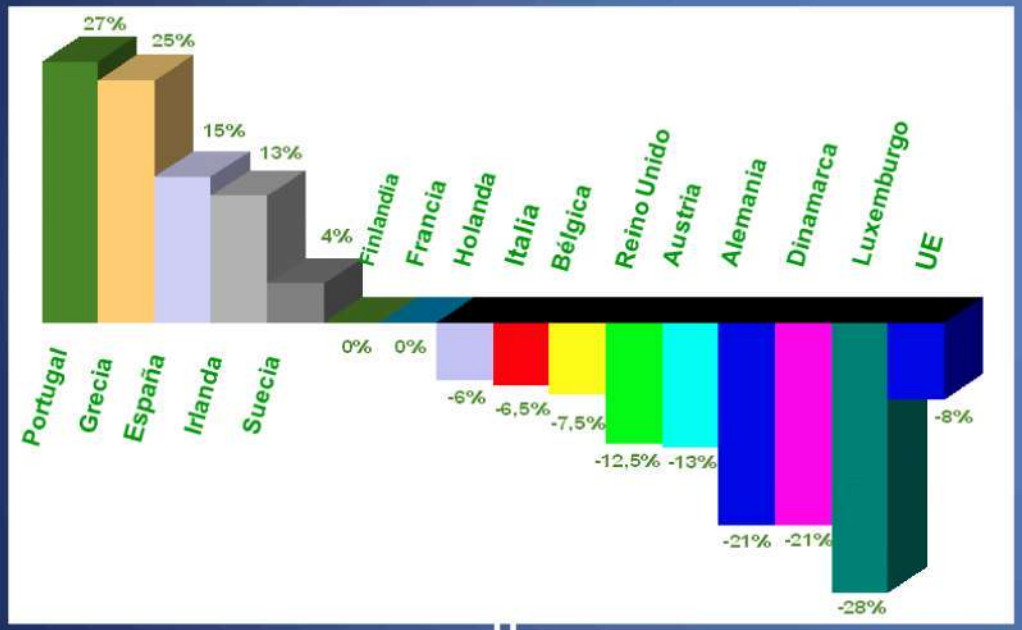
1. INTRODUCTION

Objectives: reduction of emissions of greenhouse gases



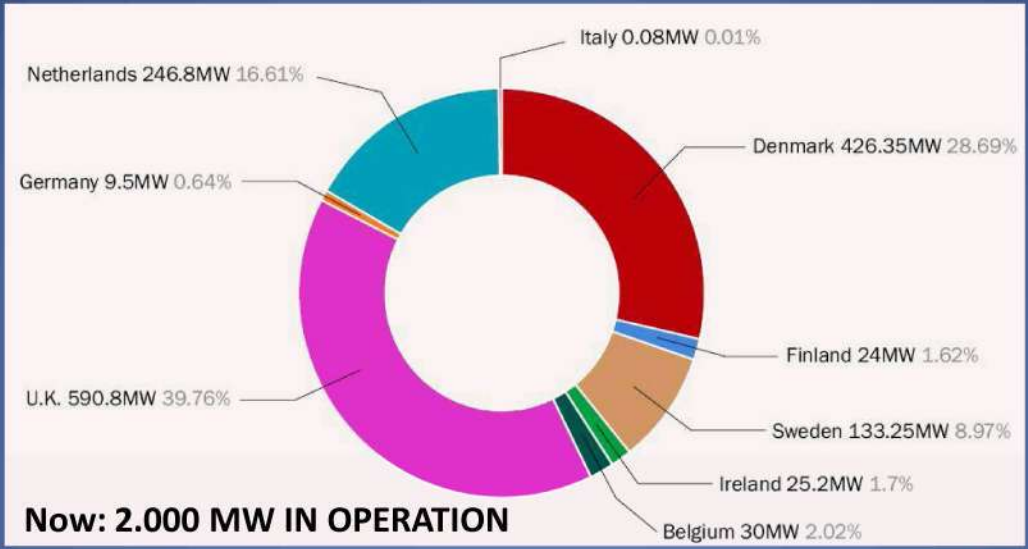
Increase of electricity demand

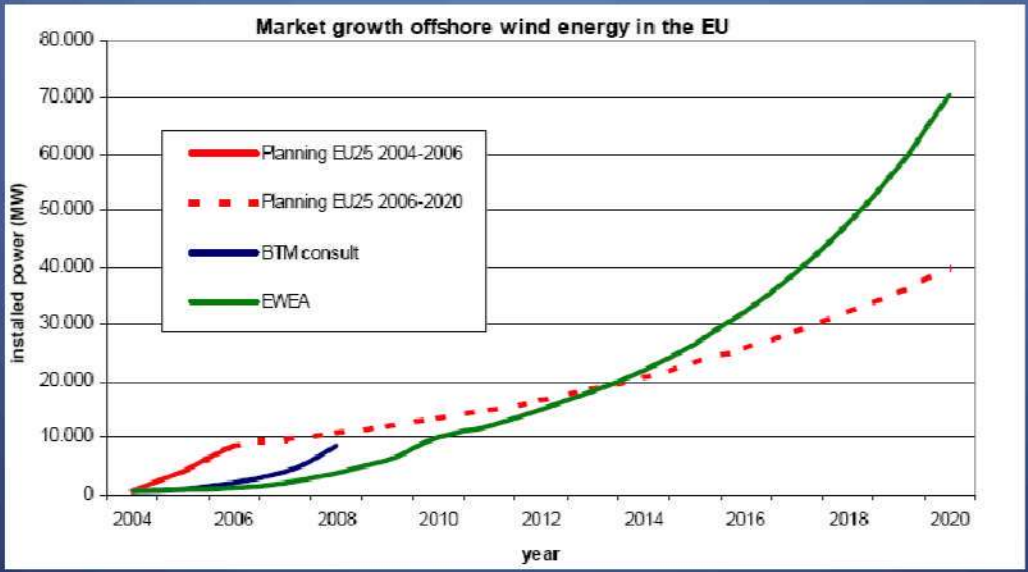
Boost of renewable energies

Wind power

1. INTRODUCTION

1. INTRODUCTION





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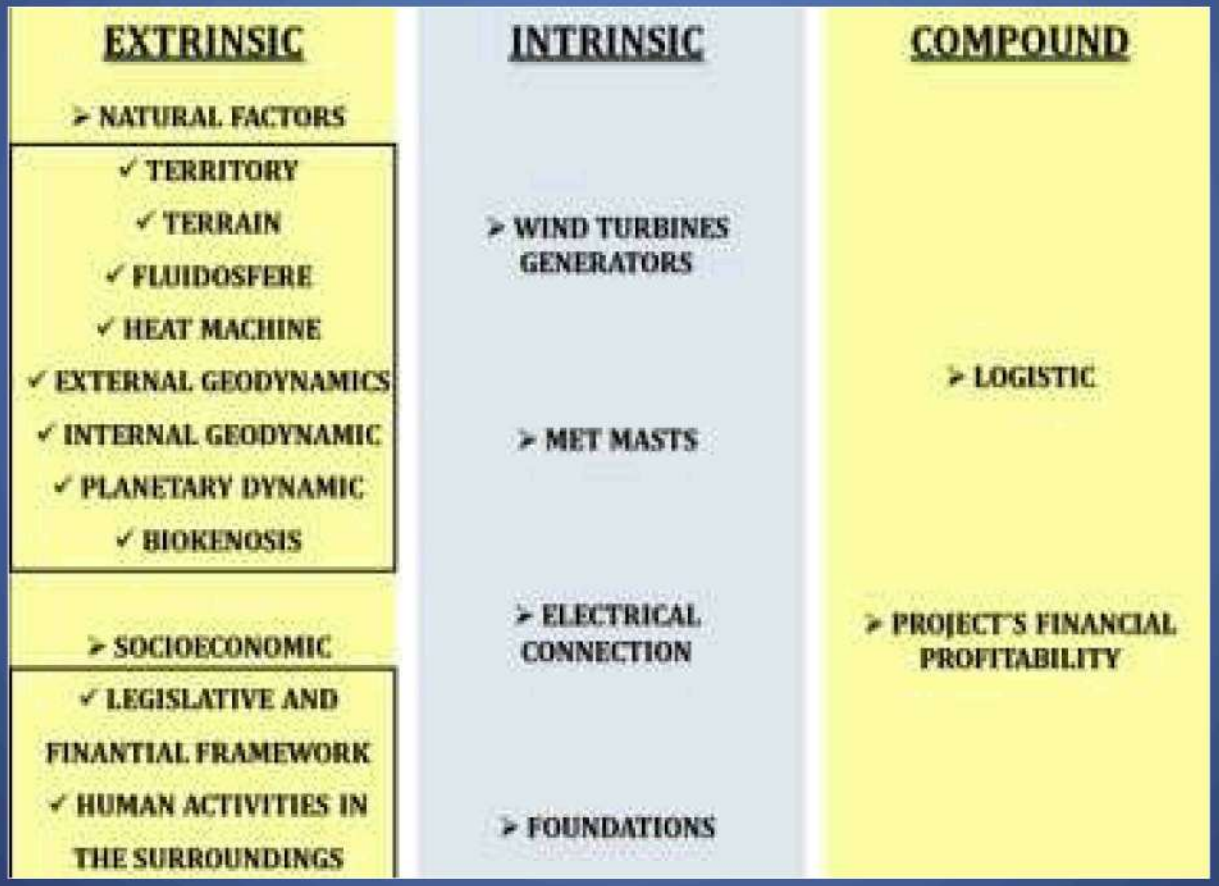
2. FACTORS


EXTRINSIC
INTRINSIC
COMPOUND
➢ NATURAL FACTORS
✓ TERRITORY
✓ TERRAIN
✓ FLUIDOSFERE
✓ HEAT MACHINE
✓ EXTERNAL GEODYNAMICS
✓ INTERNAL GEODYNAMIC
✓ PLANETARY DYNAMIC
✓ BIOKENOSIS
➢ SOCIOECONOMIC
✓ LEGISLATIVE AND FINANTIAL FRAMEWORK
✓ HUMAN ACTIVITIES IN THE SURROUNDINGS
➢ WIND TURBINES GENERATORS
➢ MET MASTS
➢ ELECTRICAL CONNECTION
➢ FOUNDATIONS
➢ LOGISTIC
➢ PROJECT'S FINANCIAL PROFITABILITY

AGENDA

1. INTRODUCTION

2. FACTORS TO BE CONSIDERED IN THE DESIGN OF OFFSHORE WIND FARMS

3. **METHODOLOGY FOR THE DESIGN OF OFFSHORE WIND FARMS**

4. CHECKING OF THE PROPOSED METHODOLOGY

3. METHODOLOGY

- ALTERNATIVE STUDY
  - GENERATION OF ALTERNATIVES
  - FEASIBILITY STUDY OF THE ALTERNATIVES GENERATED
- DESIGN OF THE ALTERNATIVE SELECTED

3. METHODOLOGY

- ALTERNATIVE STUDY
  - **GENERATION OF ALTERNATIVES**
  - FEASIBILITY STUDY OF THE ALTERNATIVES GENERATED
- DESIGN OF THE ALTERNATIVE SELECTED

3. METHODOLOGY

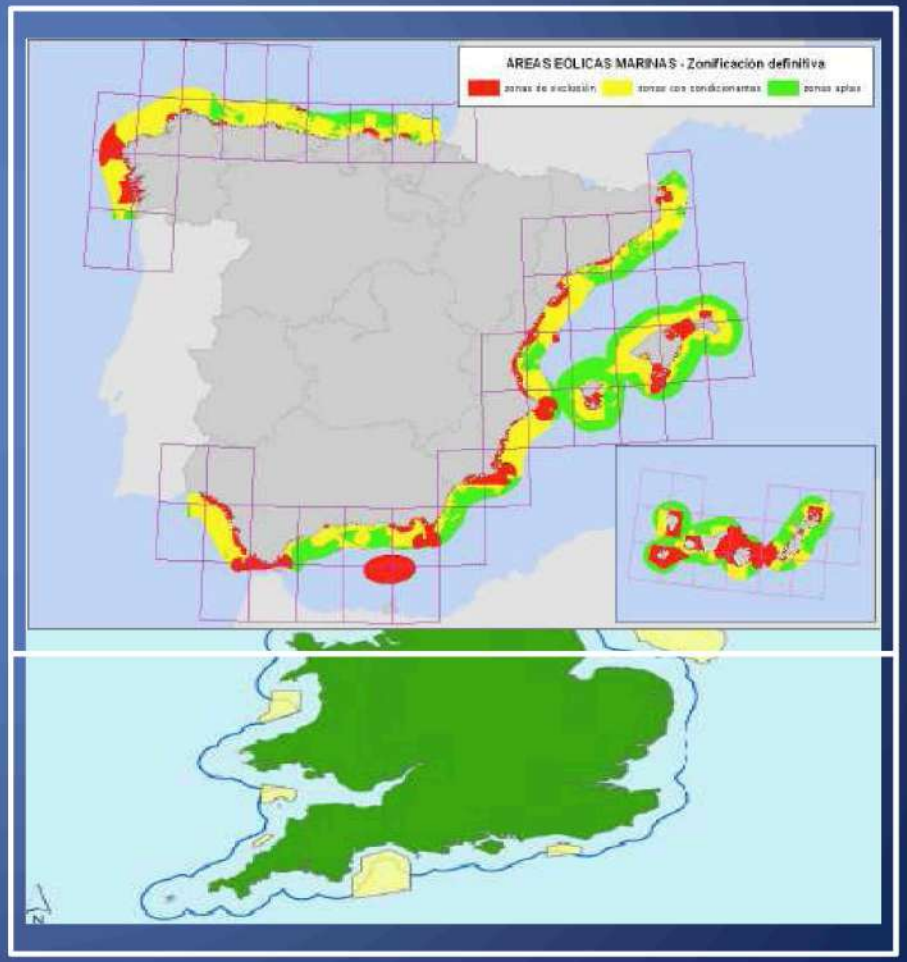
GENERATION OF ALTERNATIVES

- LEGISLATIVE AND ECONOMICAL FRAMEWORK
- WIND RESOURCE
- BATHYMETRY
- ELECTRICAL CONNECTION

3. METHODOLOGY

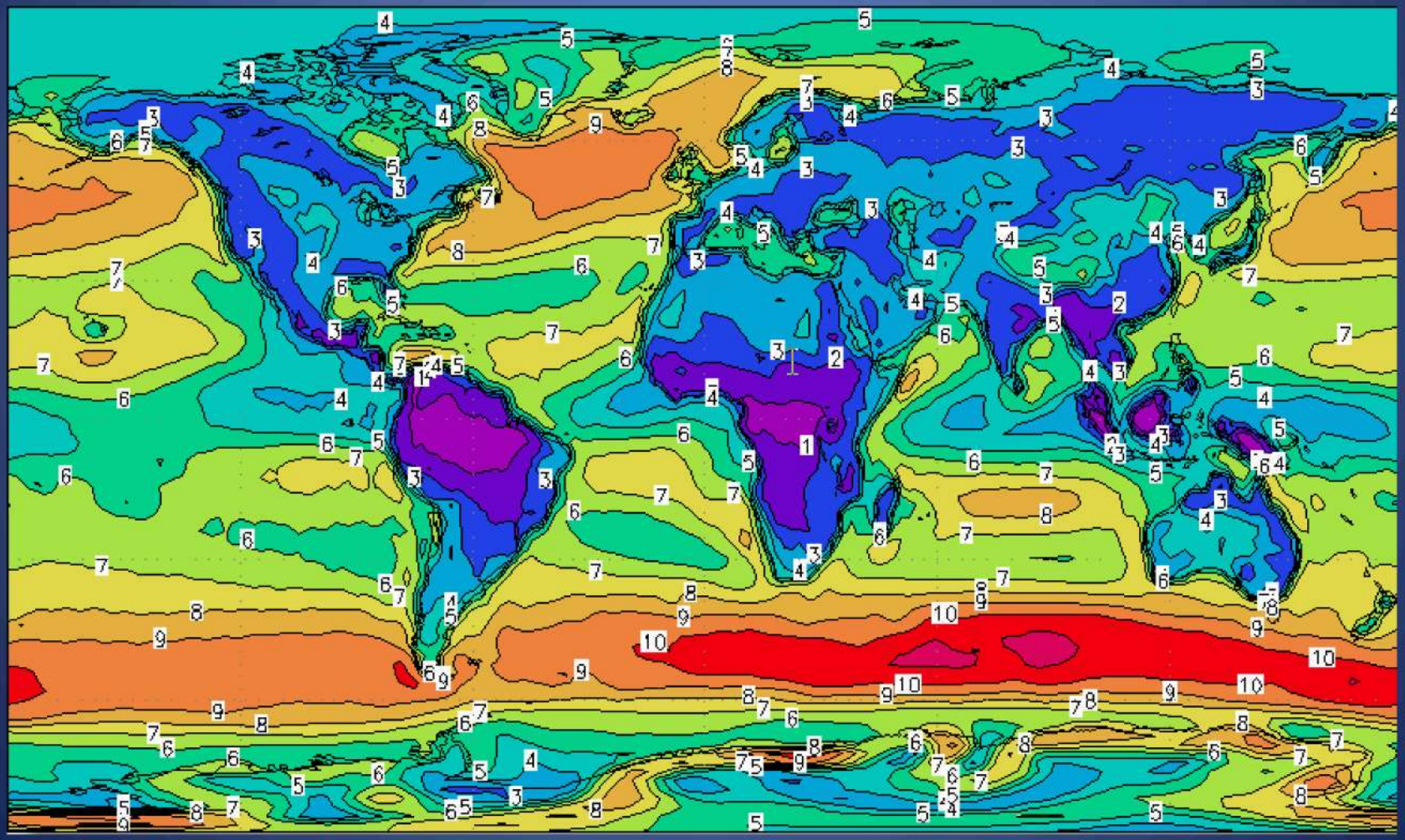
LEGISLATIVE AND ECONOMICAL FRAMEWORK

COUNTRY	LEGAL (0-20)	ECONOMICAL (0-20)	ADD
GERMANY	15	20	35
THE UK	14	20	34
BELGIUM	12	16	28
SPAIN	**11**	**16**	**27**
SWEDEN	12	11	23
DENMARK	10	11	21
FRANCE	6	15	21
IRELAND	8	11	19
SOUTH KOREA	7	11	18
TAIWAN	7	9	16
POLAND	6	10	16
HOLLAND	8	7	15
NORWAY	7	7	14
CHINA	5	9	14
JAPAN	8	5	13
ITALY	2	10	12
THE UNTED STATES	6	4	10
CANADA	2	4	6

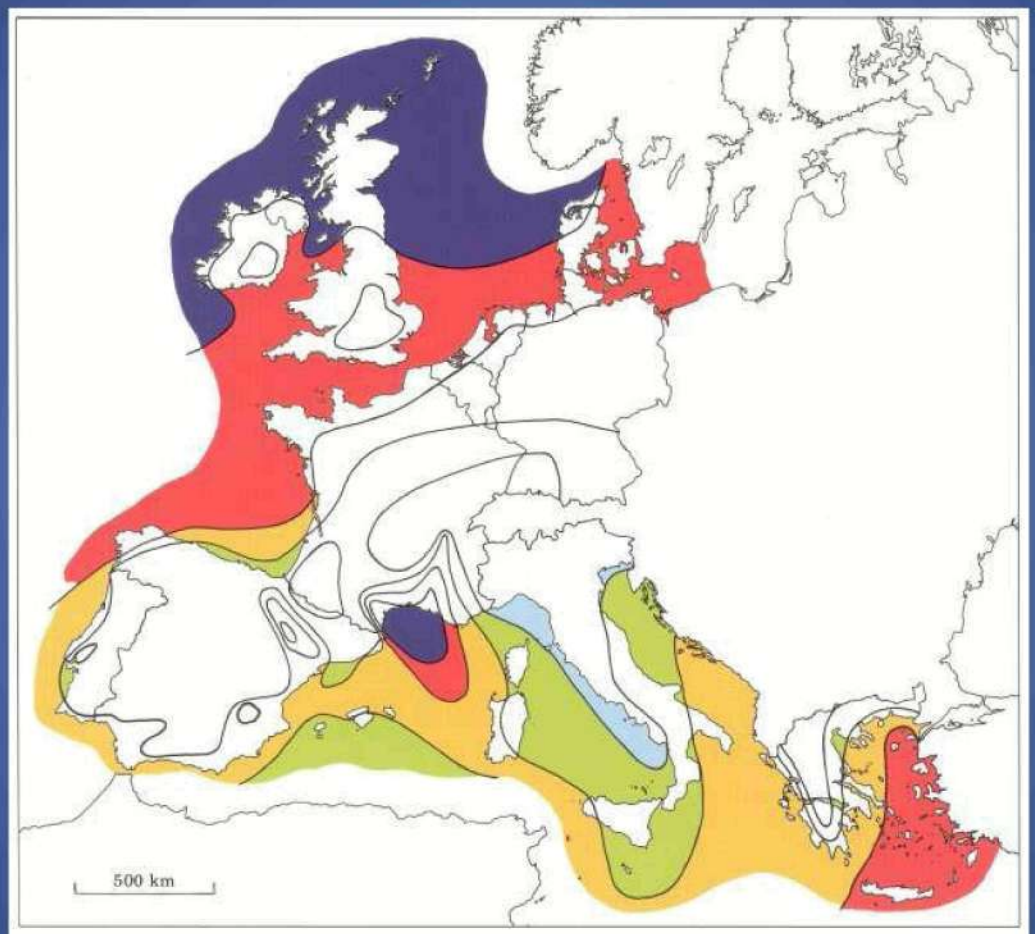


3. METHODOLOGY

WIND RESOURCE



3. METHODOLOGY



Wind resources over open sea (more than 10 km offshore) for five standard heights

	10 m		25 m		50 m		100 m		200 m	
	$m\,s^{-1}$	Wm^{-2}	$m\,s^{-1}$	Wm^{-2}	$m\,s^{-1}$	Wm^{-2}	$m\,s^{-1}$	Wm^{-2}	$m\,s^{-1}$	Wm^{-2}
	> 8.0	> 600	> 8.5	> 700	> 9.0	> 800	> 10.0	> 1100	> 11.0	> 1500
	7.0-8.0	350-600	7.5-8.5	450-700	8.0-9.0	600-800	8.5-10.0	650-1100	9.5-11.0	900-1500
	6.0-7.0	250-300	6.5-7.5	300-450	7.0-8.0	400-600	7.5- 8.5	450- 650	8.0- 9.5	600- 900
	4.5-6.0	100-250	5.0-6.5	150-300	5.5-7.0	200-400	6.0- 7.5	250- 450	6.5- 8.0	300- 600
	< 4.5	< 100	< 5.0	< 150	< 5.5	< 200	< 6.0	< 250	< 6.5	< 300

3. METHODOLOGY

- ALTERNATIVE STUDY
  - GENERATION OF ALTERNATIVES
  - **FEASIBILITY STUDY OF THE ALTERNATIVES GENERATED**
- DESIGN OF THE ALTERNATIVE SELECTED

3. METHODOLOGY

FEASIBILITY OF THE ALTERNATIVES GENERATED

- DEFINITION OF THE AREA
- INCOMPATIBILITY BETWEEN ENVIRONMENT AND INSTALLATION
- LAY-OUTS
- COST-EFFECTIVENESS ANALYSIS

3. METHODOLOGY

DEFINITION OF THE AREA

- Factors before mentioned
- Distance to the coast
- Human activities
- Landscape
- Restriction of power

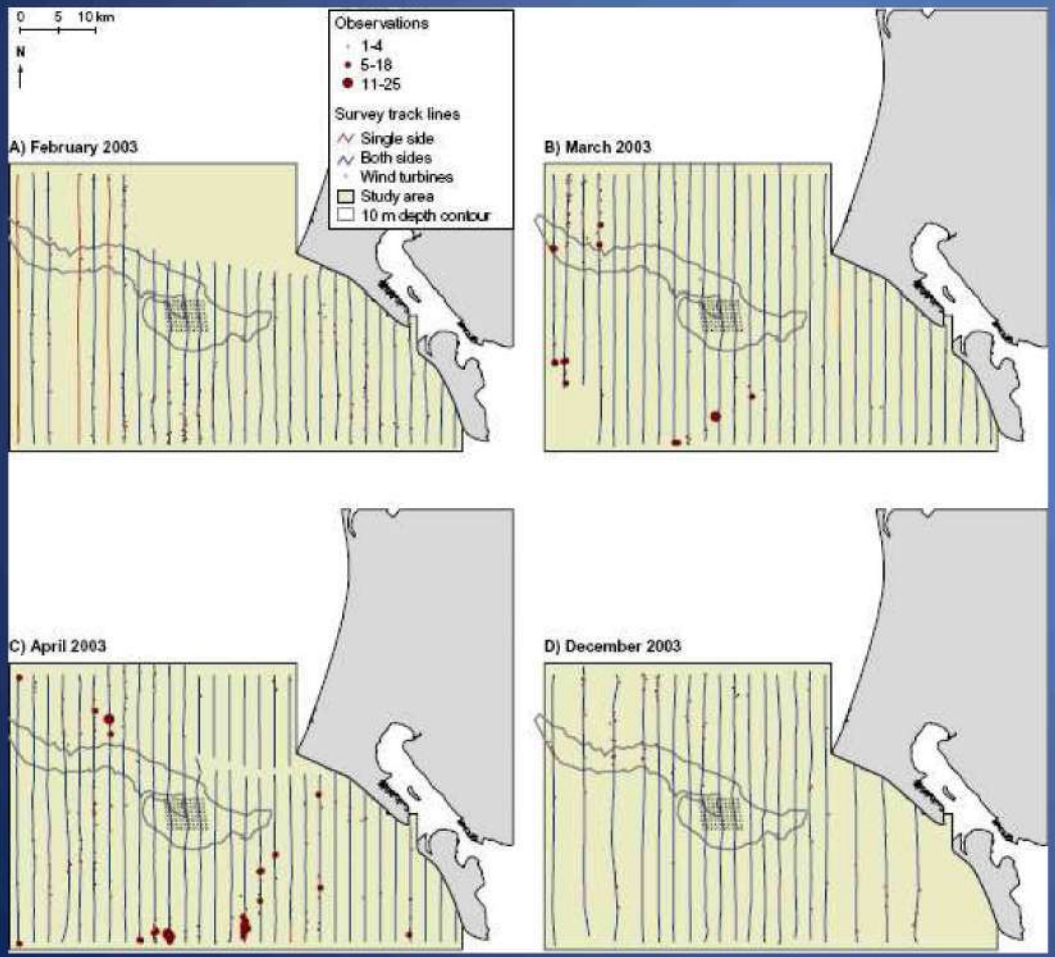
3. METHODOLOGY

¿INCOMPATIBILITY BETWEEN ENVIRONMENT AND INSTALLATION?

- Earkquake, tsumamis, etc.
- Wind resource
- Terrain
- Biokenosis (flora and fauna)
- Ocean climate (waves, currents, etc.)

3. METHODOLOGY

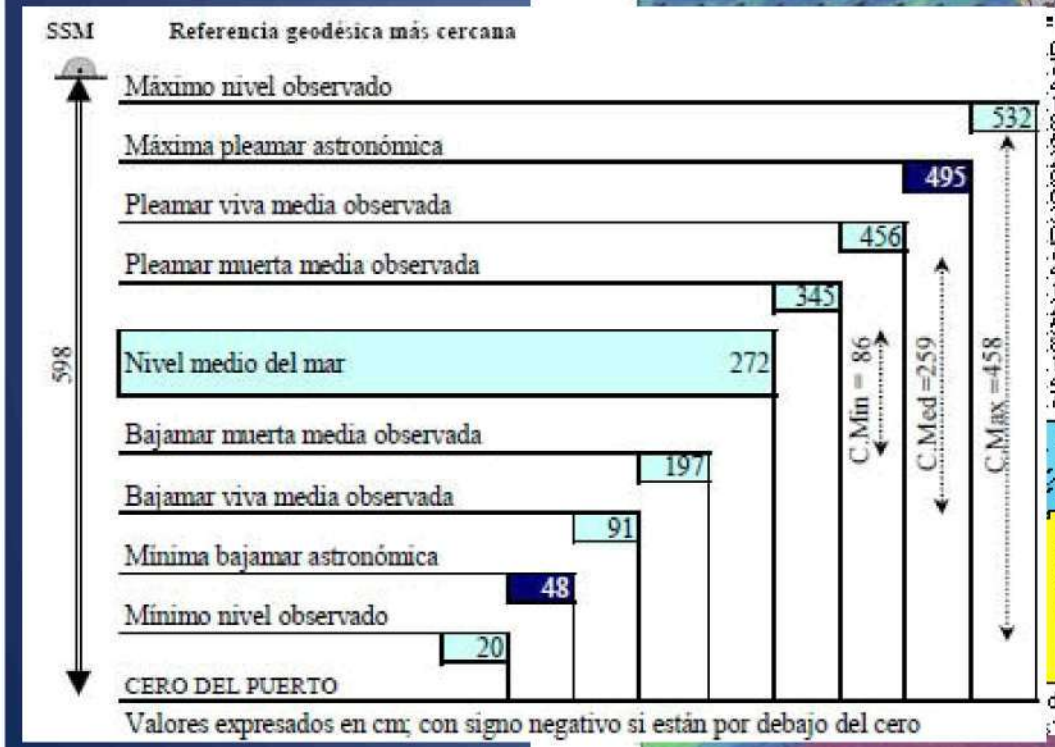
BIOKENOSIS



Posidonia oceanica: se pueden encontrar hasta los 50 – 60 metros de profundidad

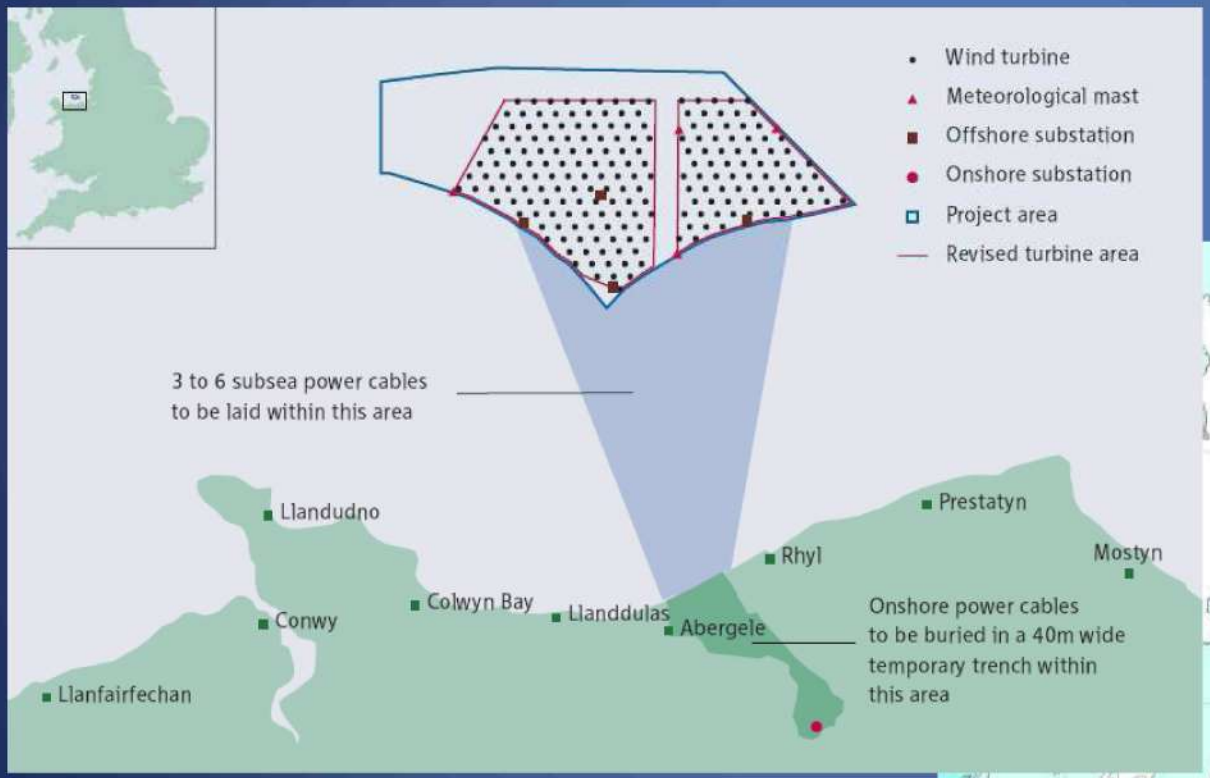
3. METHODOLOGY

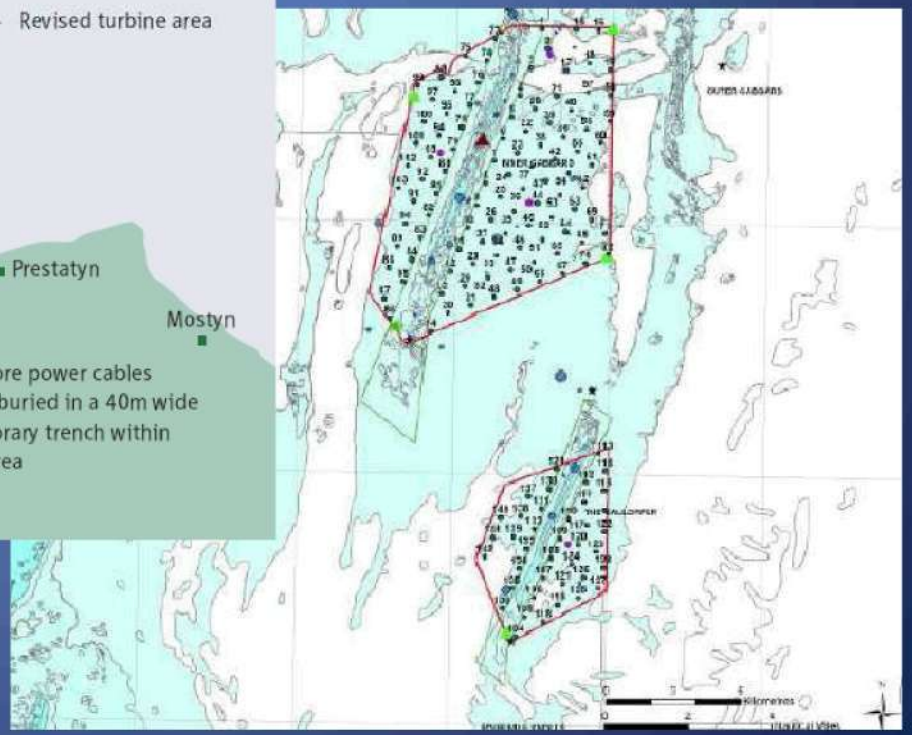
OCEAN CLIMATE



3. METHODOLOGY

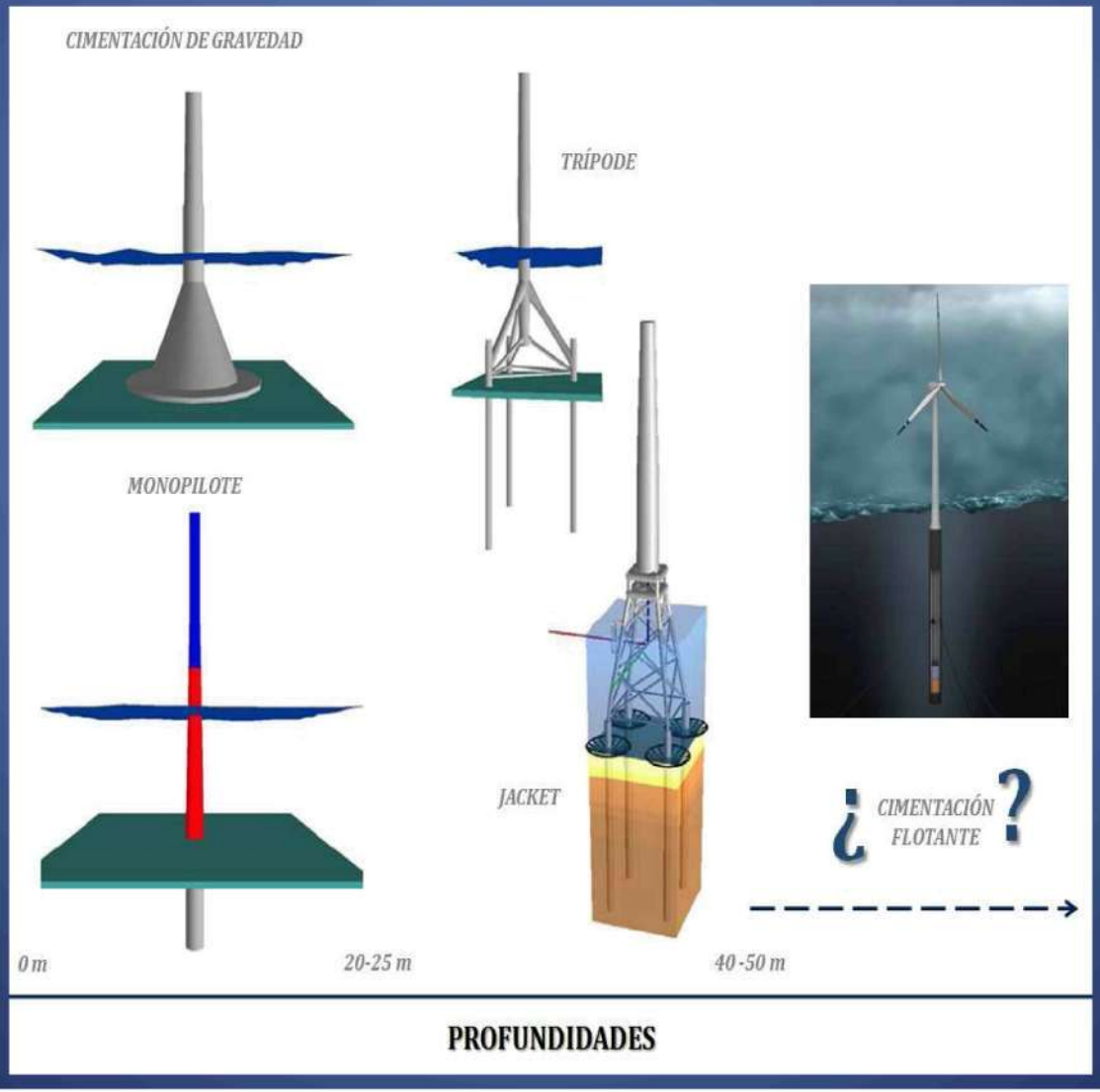
LAY-OUTS



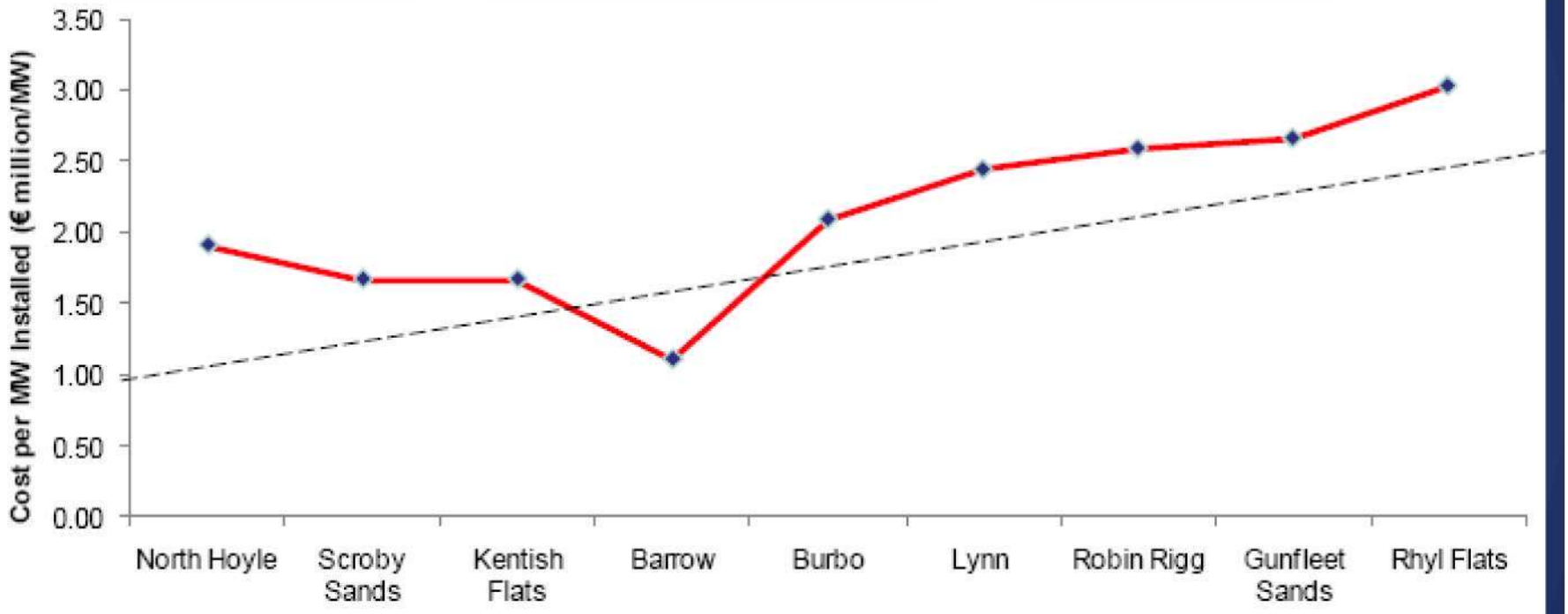


3. METHODOLOGY

COST-EFFECTIVENESS ANALYSIS



3. METHODOLOGY



Construction Year	2003	2004	2005	2006	2007	2008	2008	2008	2009*
Capacity (MW)	60	60	90	90	90	195	180	108	90

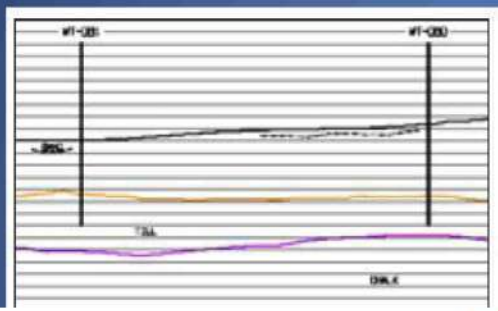
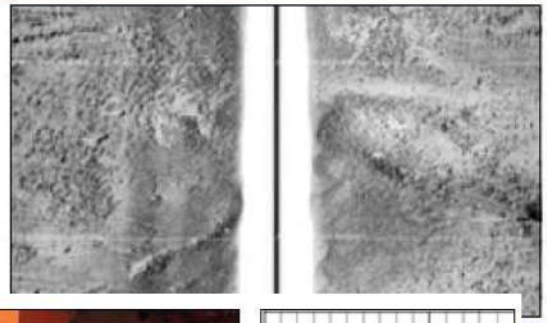
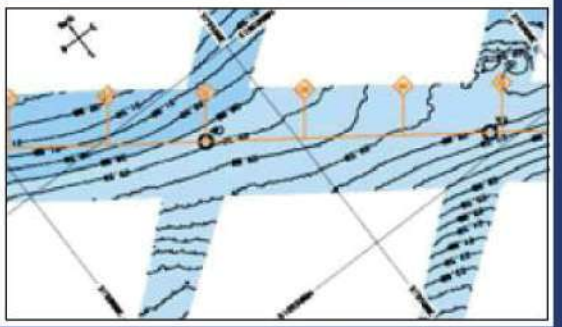
3. METHODOLOGY

DESIGN OF THE ALTERNATIVE SELECTED

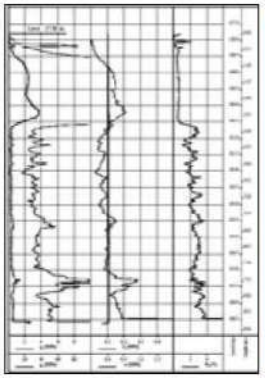
- IMPROVEMENT OF THE KNOWLEDGE OF THE LOCATION
- IMPACT OF THE INSTALLATION OVER THE ENVIRONMENT
- DETAILED DESIGN
- CHECKING OF THE COST-EFFECTIVENESS ANALYSIS

3. METHODOLOGY

IMPROVEMENT OF THE KNOWLEDGE OF THE LOCATION

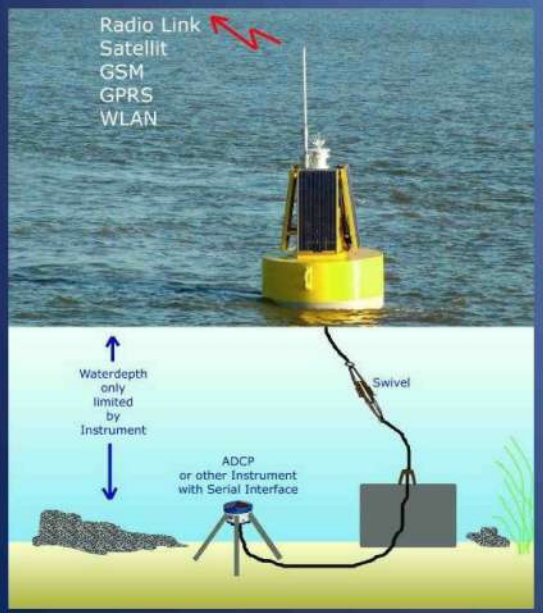




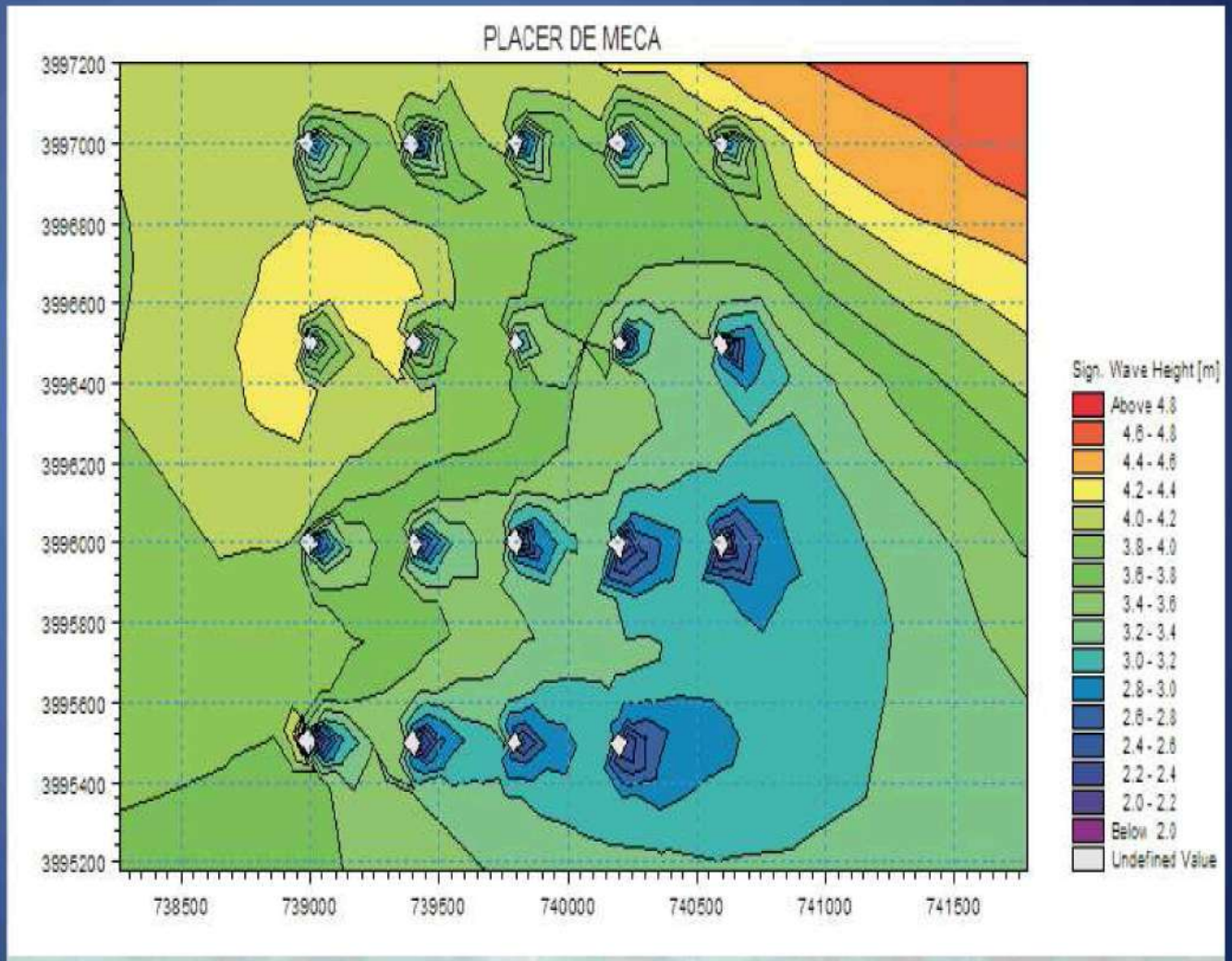






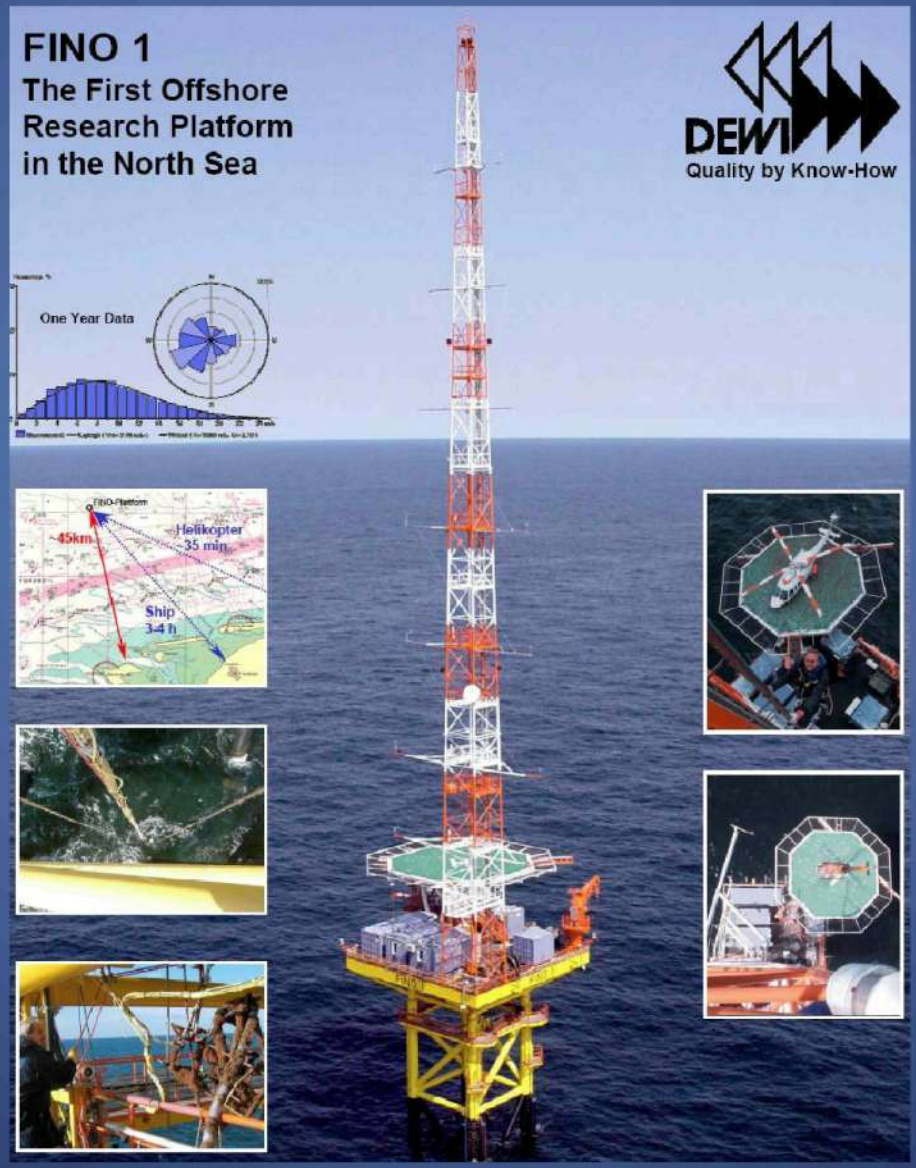
3. METHODOLOGY





Efecto del parque eólico en el oleaje N060ºW

3. METHODOLOGY



3. METHODOLOGY

IMPACT OF THE INSTALLATION OVER THE ENVIRONMENT

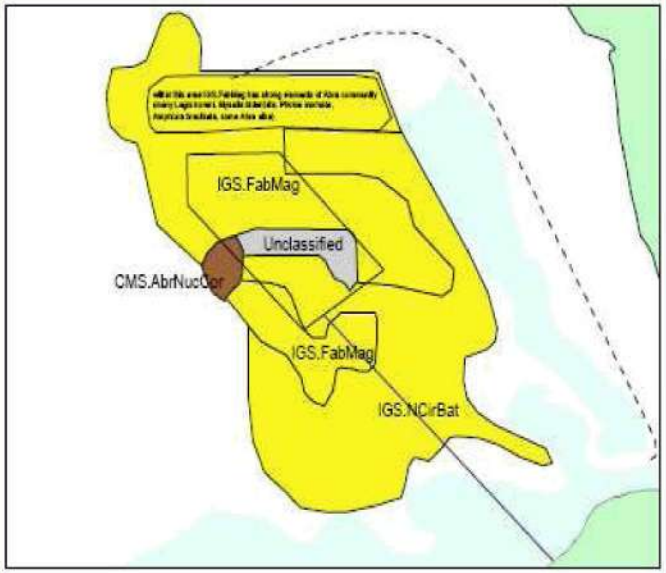
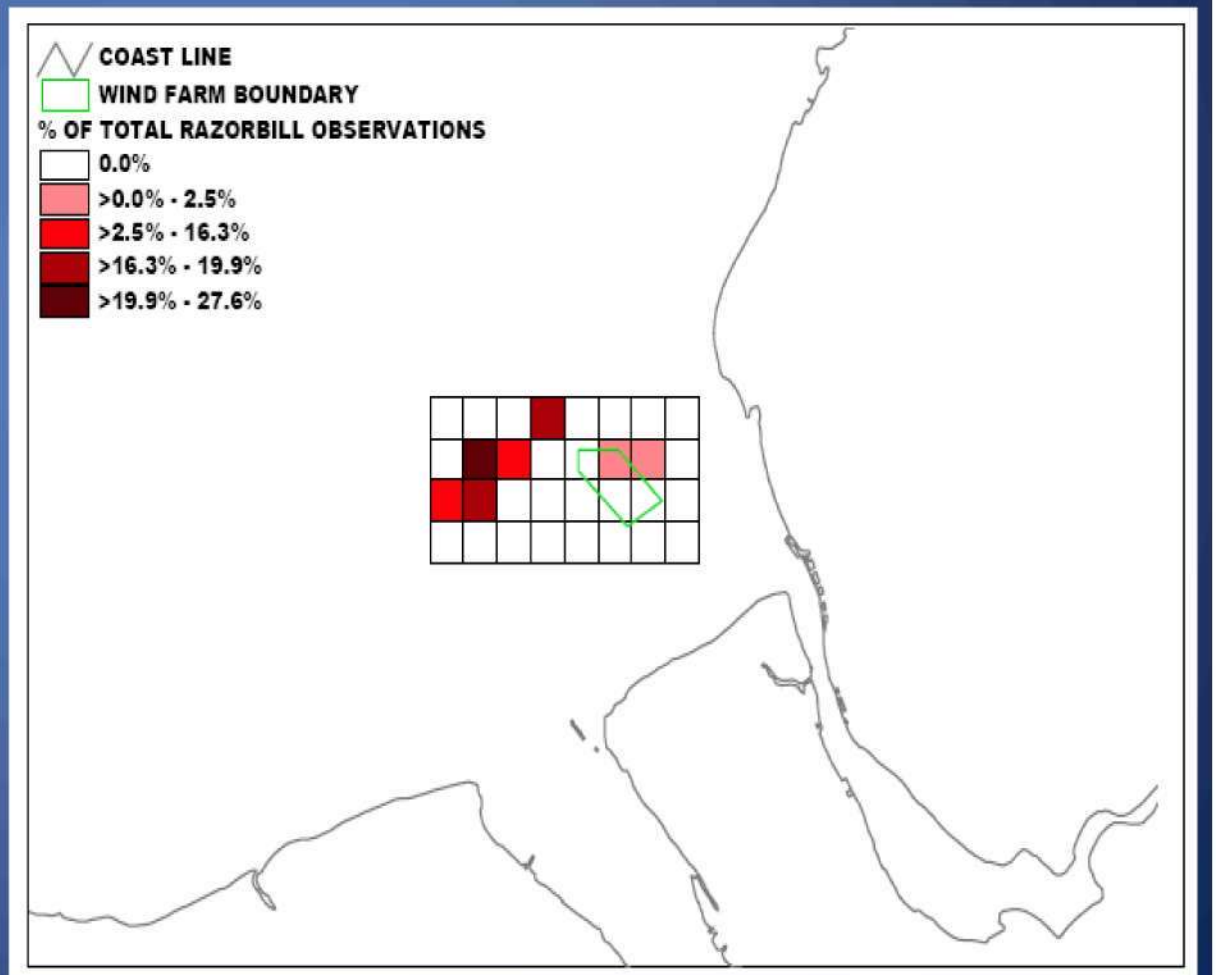
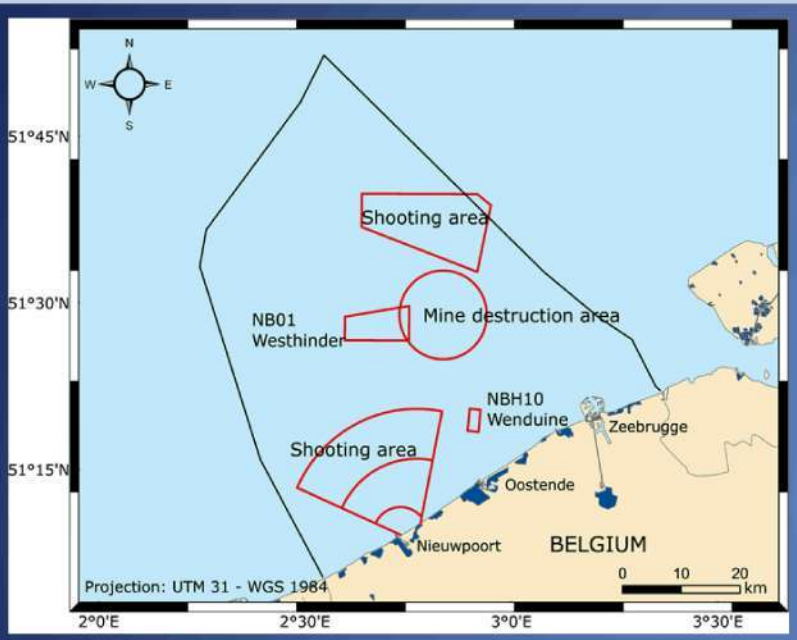


Figure 5.3: Indicative biotope map of the Burbo Flats area

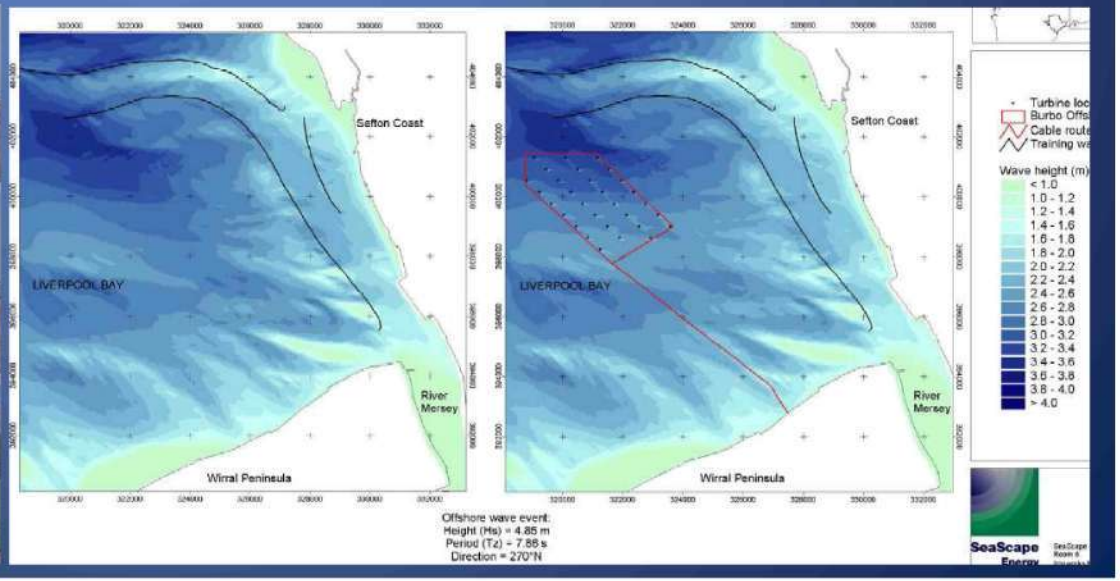
IGS.FabMag	*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves in infralittoral compacted fine sand
CMS.AbrNucCor	*Abra alba*, *Nucula nitida* and *Corbula gibba* in circalittoral muddy sand or slightly mixed sediment
IGS.NcirBat	*Nephtys cirrosa* and *Bathyporeia* spp in infralittoral sand
Unclassified	Some overlap with IGS.NcirBat but considerably richer, and characterised by the presence of quite high numbers of *Nephtys caeca* and *Nephtys hombergi*, *Phoronis muelleri*, *Pharus legumen*, *Mysella bidentata*, and *Pholoe inornata*.



3. METHODOLOGY

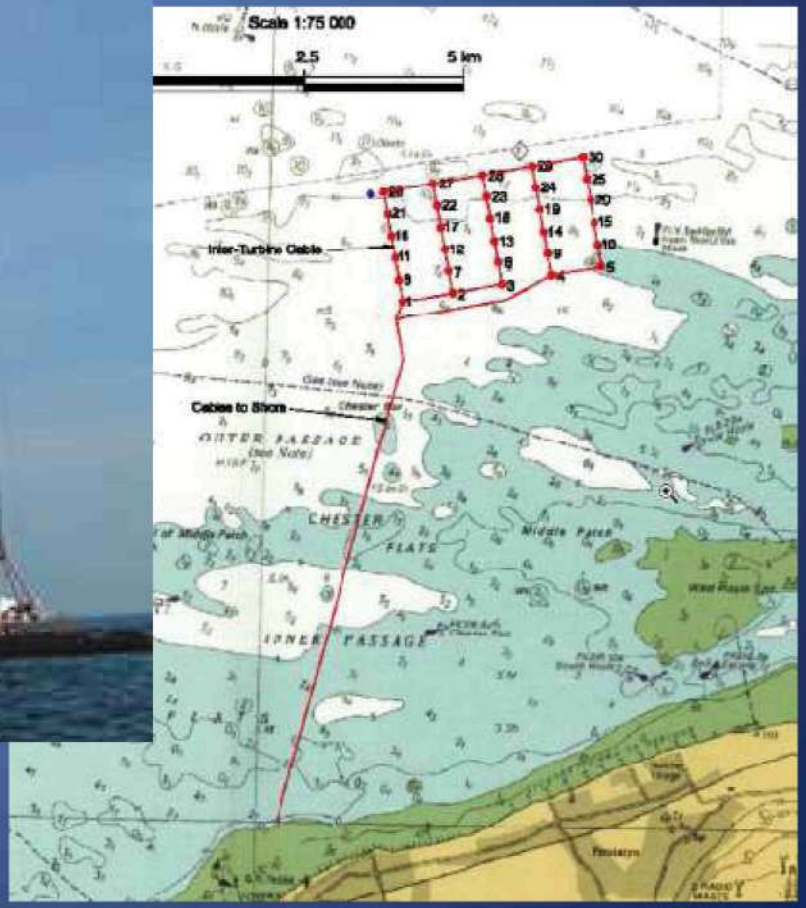


Accident Event	Annual Frequency	Return Period (Years)
Powered Passing Ship Collision	3.9×10^{-5}	25,600
Drifting Ship Collision	2.6×10^{-4}	3,800
Fishing Vessel Collision	3.0×10^{-5}	33,300
Total	**3.3×10^{-4}**	**3,000**

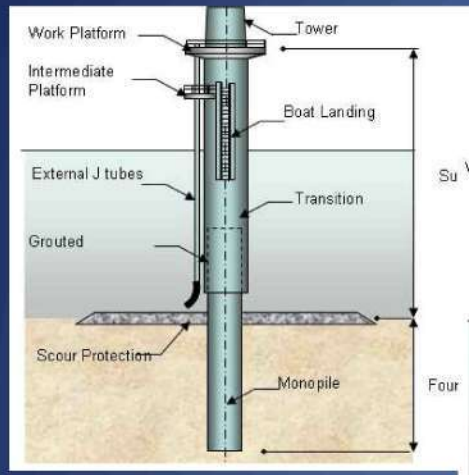


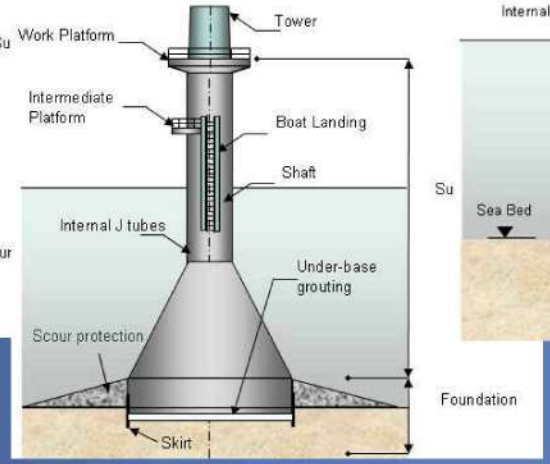
3. METHODOLOGY

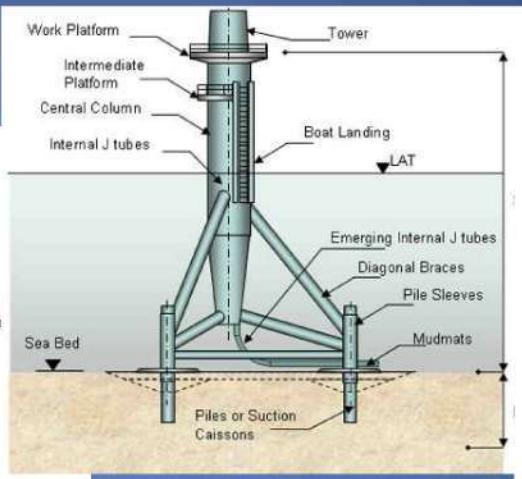
DETAILED DESIGN (Electrical, foundations, etc.)

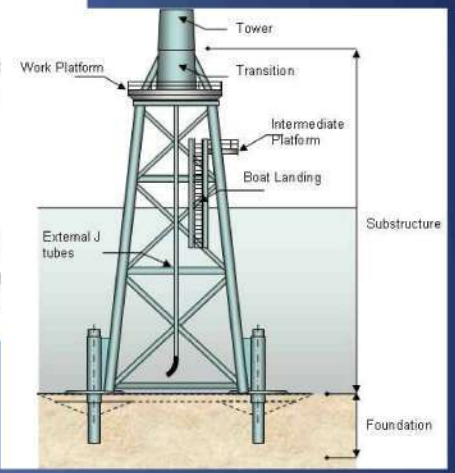


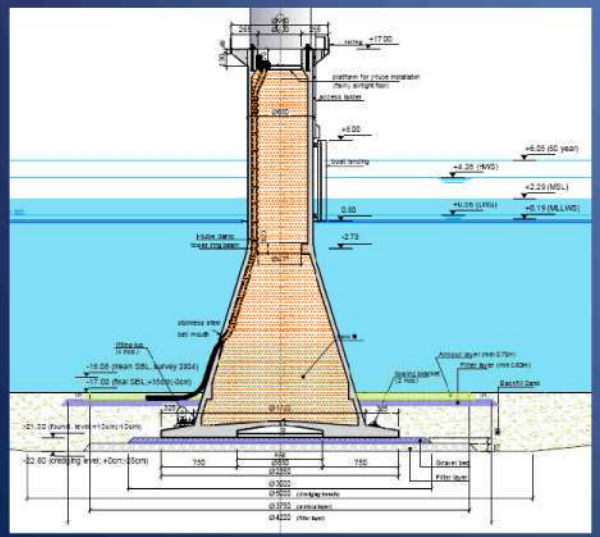
3. METHODOLOGY



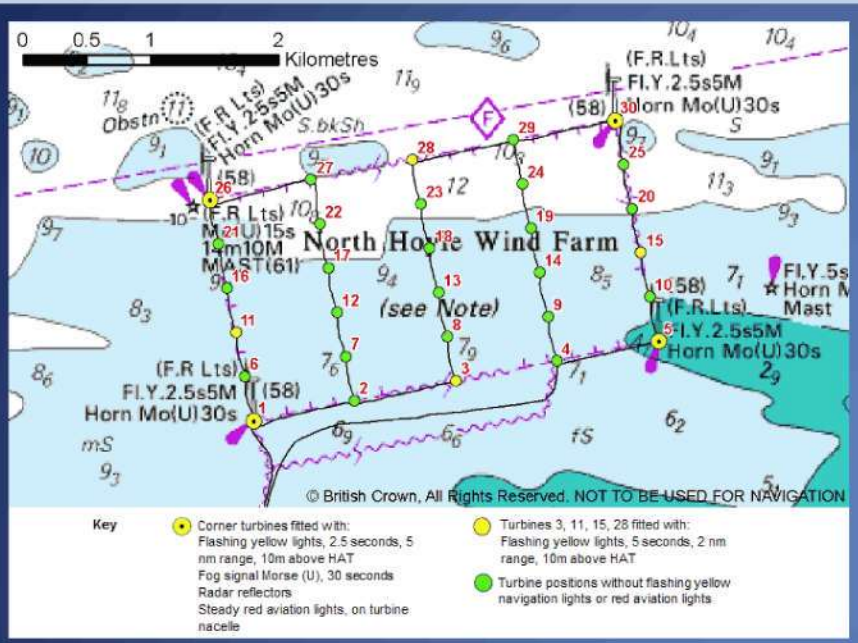


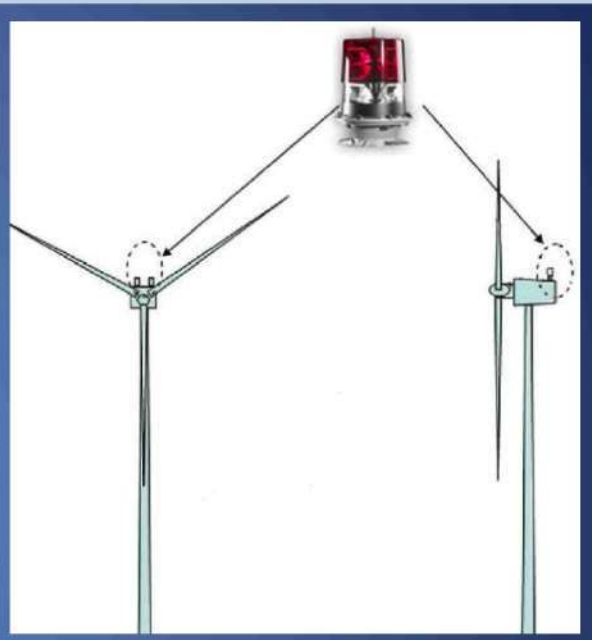






3. METHODOLOGY





WBS	WORKS	DESIGN DATA	DESIGN BASIS	DETAIL DESIGN	DESIGN APPROVAL	SUPPLY	SUPPLY APPROVAL	FABRICATION	FABRICATION APPROVAL	TRANSPORTATION TO SITE	TRANSPORTATION APPROVAL	INSTALLATION	INSTALLATION APPROVAL	COMMISSIONING	COMMISSIONING APPROVAL
1	Wind Turbine Generator (WTG)	1	2	2	3	2	1	2	1	2	1	4	1	2	1
2	WTG Foundation	1	1	1	3	5	1	5	1	5	1	6	1	6	1
3	Offshore Transformer Substation (OTS)	1	7	7	3	8	1	7	1	7	1	9	1	8	1
4	OTS Foundation	1	1	1	3	5	1	5	1	5	1	6	1	6	1
5	Offshore Export Cable	1	10	10	3	10	1	10	1	11	1	11	1	10	1
6	Offshore Infield Cables	1	10	10	3	10	1	10	1	10	1	12	1	12	1
7	Offshore Living Quarter	1	13	13	3	13	1	13	1	13	1	9	1	13	1
8	Scour Protection	1	14	14	3	14	1	14	1	14	1	14	1	14	1
9	Onshore Substation (OS)	1	15	15	3	15	1	15	1	15	1	15	1	15	1
10	Onshore Cables	1	16	16	3	16	1	16	1	16	1	16	1	16	1

AGENDA

1. INTRODUCTION

2. FACTORS TO BE CONSIDERED IN THE DESIGN OF OFFSHORE WIND FARMS

3. METHODOLOGY FOR THE DESIGN OF OFFSHORE WIND FARMS

4. **CHECKING OF THE PROPOSED METHODOLOGY**

4. CHECKING

¿HOW?

Use of the methodology with different offshore wind farms

DIFICULTIES

to obtain the required information, because of:

- Scarce experience in offshore wind
- Confidential informartion

⇩

COMPLEX PROCCESS OF SELECTION

4. CHECKING

PROYECTOS SELECTED:

Thornton Bank (Bélgica)

Beatrice (UK)

Burbo (UK)

London Array (UK)

Egmon aan Zee (Holanda)

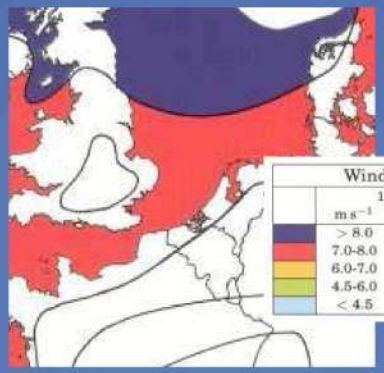
Horns Rev (Dinamarca)

Middelgrunden (Dinamarca)

4. CHECKING

Generation of alternatives:

PAÍS	LEGISLACIÓN (0-20)	INCENTIVOS REGULATORIOS (0-20)	SUMA
ALEMANIA	15	20	35
REINO UNIDO	14	20	34
BÉLGICA	12	16	28
ESPAÑA	**11**	**16**	**27**
SUECIA	12	11	23
DINAMARCA	10	11	21
FRANCIA	6	15	21
IRLANDA	8	11	19
COREA SUR	7	11	18
TAIWAN	7	9	16



Wind resources over open sea (more than 10 km offshore) for five standard heights

	10 m		25 m		50 m		100 m		200 m	
	$m\,s^{-1}$	Wm^{-2}	$m\,s^{-1}$	Wm^{-2}	$m\,s^{-1}$	Wm^{-2}	$m\,s^{-1}$	Wm^{-2}	$m\,s^{-1}$	Wm^{-2}
	> 8.0	> 600	> 8.5	> 700	> 9.0	> 800	> 10.0	> 1100	> 11.0	> 1500
	7.0-8.0	350-600	7.5-8.5	450-700	8.0-9.0	600-800	8.5-10.0	650-1100	9.5-11.0	900-1500
	6.0-7.0	250-300	6.5-7.5	300-450	7.0-8.0	400-600	7.5- 8.5	450- 650	8.0- 9.5	600- 900
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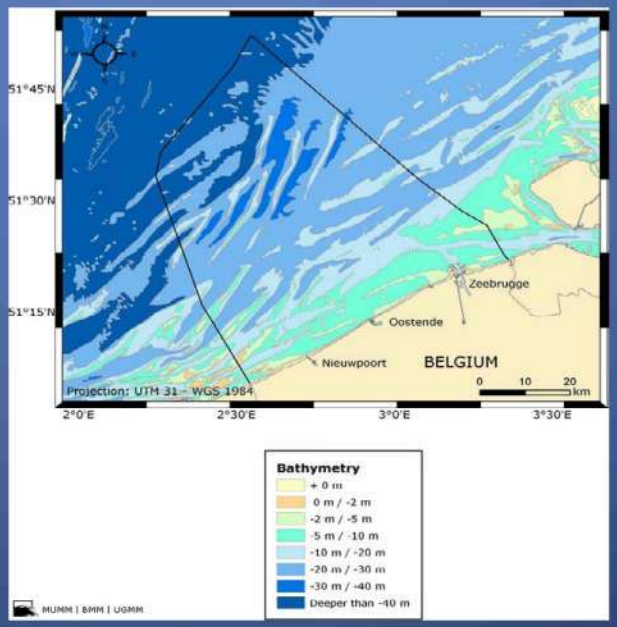
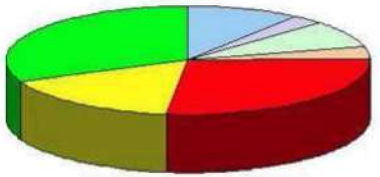


4. CHECKING

Feasibility analysis of the alternative selected:

Figure 8: Geometry and relationships between solid units (Tertiary). Example of a seismic section (A) and its interpretation (B), realised above the Thorntonbank and orientated NE-SW (see location on C) (after Maréchal et al., 1986).

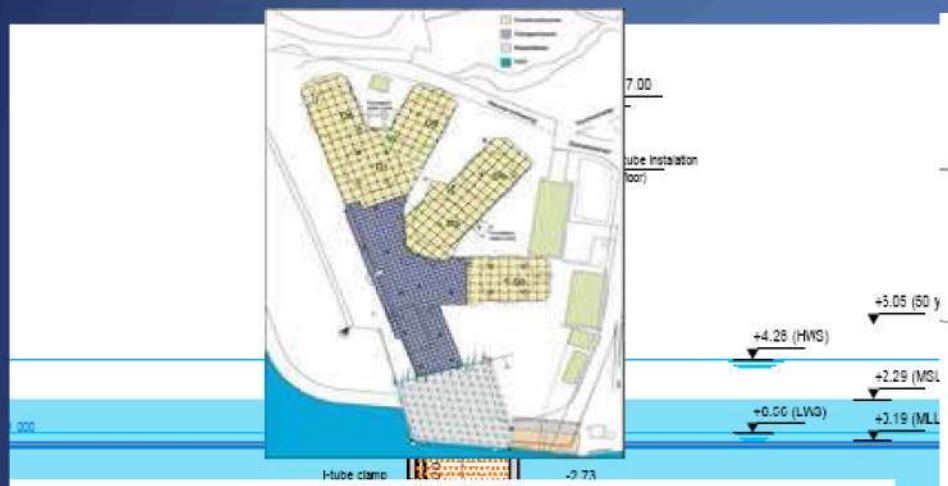
Investment Cost Phase 1 (6 WTG):
€ 152.8 million

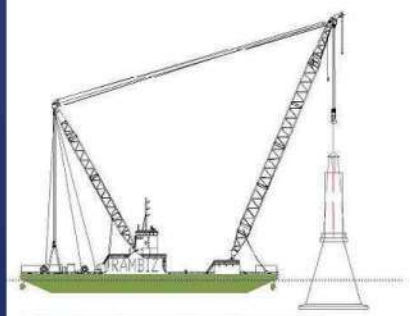


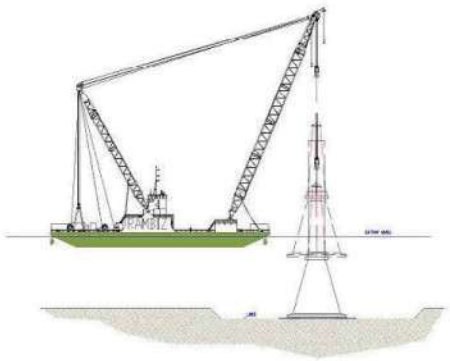
- Development/ Engineering
- Insurance
- Finance
- Contingency
- Cable connection
- Foundation
- Windturbines

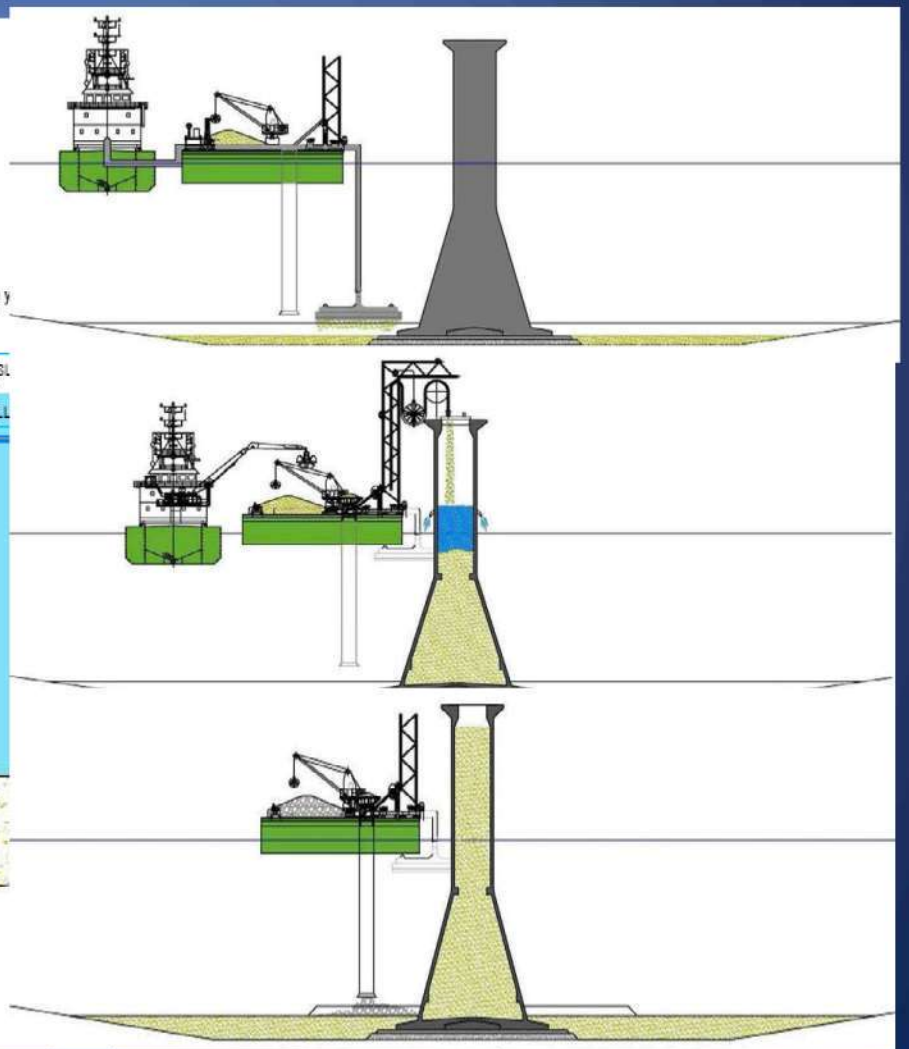
4. CHECKING

Checking of the proposed methodology:










THANK YOU VERY MUCH